PATENT SPECIFICATION 830,018

DRAWINGS ATTACHED.

Date of filing Complete Specification : March 11, 1958.

Application Date : March 13, 1957. No. 8236/57.

Complete Specification Published : March 9, 1960.

Index at Acceptance:—Class 38(5), K1(A2A:D:F), K(15:17:19:20).

International Classification:—H02d.

COMPLETE SPECIFICATION.

Protective Device for Electrical Circuits and Apparatus.

I, MICHAEL CORNELIUS GERRARD, a British Subject, of 18 Highfield Road, Cheadle Hulme, Cheshire, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with a device for protecting alternating current electrical circuits and apparatus, in particular portable apparatus, against dangers arising through faults and also against those arising through incorrect connections being made.

A large proportion of portable domestic electrical appliances such as suction cleaners, hair dryers, lawn mowers, electric blankets, portable drills, are at the present day still only fitted with two-core cables, having live and neutral only, and there is no legal compulsion for the provision of an earth conductor. The consequent danger of the appliance becoming electrically live is increased if in addition the leads are connected wrongly to the supply so that the single-pole switch is in the neutral instead of in the live conductor.

Where three pin earthed supply sockets are provided there is still nothing to ensure that three-core cable is used to the appliance, and furthermore even where three-core cable is used there is no certainty that it will be connected correctly. When it is appreciated that there are six different possible ways of connecting three wires to three terminals, only one of which is correct, it will be understood that it is very easy for an appliance to be wrongly connected to a plug by inexperienced hands. Frequently the appliance works satisfactorily and the danger is not realised until an accident results.

Again, even with the appliance correctly wired to the plug, any interruption of the earth conductor will not be detected and the appliance will continue to be used in a potentially dangerous state. In industry the earth connection of portable appliances is often checked by discharging a heavy current through it from a test instrument from time to time, but no such check protects the domestic user of appliances.

It is known to provide various kinds of safety device including differential transformers and relays, earth-leakage relays, and also transformers of which the secondary winding produces a low-voltage output which causes a current to circulate in the earth lead of the appliance to be protected. However, none of these devices so far proposed has ensured firstly that the earth connection is continuous right back to its point of union with the neutral line of the mains supply, and secondly that the appliance cannot be connected, even momentarily, unless the connections are substantially correct.

The aim of the invention is to overcome these drawbacks and to provide, as far as possible, an effective safeguard both against incorrect connection of the apparatus and against failure of the earth conductor, in addition to the usual fusible links in the supply protecting against overloads and short-circuits.

According to the invention an electrical protective device for interposition between an alternating current mains supply, which includes an earth conductor and a current-consuming appliance, comprises a relay or circuit-breaker having contacts which open to isolate the apparatus from the supply, the operating coil of the relay or circuit-breaker deriving its operating voltage from a source dependent on the sum of two magnetic fluxes or from the sum of voltages derived from two magnetic fluxes, the fluxes being derived from the voltages across two pairs of conductors of the device, one of these conductors being the earth conductor, whereby if the sum of the fluxes or of the

voltages is substantially below its correct value the relay or circuit-breaker will remain open and the appliance will be isolated from the supply.

In the case of a single phase supply the current for the operating coil of the relay or circuit-breaker may for example be derived from a potential source comprising the series-connected secondaries of two transformers, the primaries of which are connected respectively one between the conductor intended to be connected to the live terminal of the supply and the conductor intended for earth, the other between that intended for the live terminal and that intended for the neutral. If the three conductors are correctly connected to live, neurtal and earth of the supply, then there will be substantially the full supply voltage across each primary and the resulting secondary voltages, which add up, are arranged to be sufficient to close the relay or circuit-breaker. If, however, any or almost any of the connections are interchanged, or if there is a break in a conductor, one or other or both of the voltages will not appear and the relay contacts will remain open, isolating the appliance from the supply. It will be appreciated that this circuit according to the invention checks the continuity of the earth connection right back to the point of the mains supply where earth and neutral become common.

According to a further feature of the invention provision is made for the passing of a current continuously through the protective earth sheath of the appliance, and any interruption of this current, such as would be caused by damage to the sheath, will isolate the appliance from the supply. For example the current to the operating coil of the relay or circuit-breaker mentioned earlier could be passed through the sheath. In an electrically heated blanket, warming pad, mattress or the like, for example, the heating element may be enclosed in a continuous braided flexible metal covering of which one end is earthed and of which the two ends are connected in series with the transformer secondaries mentioned earlier. Then any fracture of the braided covering will interrupt the supply to the coil of the relay or circuit-breaker (hereinafter referred to as a circuit-breaker) and isolate the appliance.

Two examples of electrical safety devices and a modification will now be described by way of example with reference to the accompanying drawings, in which:—

Figure 1 shows the circuit diagram of one form of the device, also indicating the connections to the appliance.

Figure 2 shows the circuit of a modified form, omitting the differential current relay.

Figure 3 shows a modification which may be embodied in either of the circuits of Figures 1 and 2.

Referring first to Figure 1, this shows a form of the device giving maximum protection. The input terminal board or plug is shown at 1, having terminals N, E and L respectively for connection of the neutral, earth and live connections of a single phase, alternating current supply. Normally the supply will be in the form of one phase of a three-phase alternating current supply network and at some point in the network there will be a star-connected transformer the secondary winding of which has its central star joint earthed. The earth wire of the consumer's installation will normally also be connected to an earthing rod or other conductor buried in the ground, and if all the earth connections are correct this earth path should have a resistance low enough to allow any earth faults to circulate through it.

The device according to the invention has, broady speaking, three conductors 2, 3 and 4 running through it, each broken by a circuit breaker A, and a further circuit breaker B. The live and neutral conductors 2 and 4 each have protective fuses F and series windings 5 and 6 on the outer limbs of a differential current relay C of special construction, to be described later, and then all three conductors lead to an output terminal board or socket 7, which includes an extra earth terminal E_2 in addition to an earth terminal E_1.

A transformer T has a three-limbed core with two primary windings 8 and 9 and, on the central limb, a single low-voltage secondary winding 10. It will be understood that the transformer T may be replaced equally well by two separate transformers having their secondary windings connected in series. One primary winding 8 is connected through a conductor 11, conductor 12, the contacts of a push-button 13, and a fuse 14 between the neutral conductor 2 and live conductor 4. The other primary winding 9 is connected through a conductor 15, and the same conductor 12, contacts 13 and fuse 14 between the earth conductor 3 and live conductor 4.

A connection from one side of the secondary winding 10 is taken through a fuse 16 to the operating coil 17 of the circuit-breaker B and thence to the terminal E_2, and there is a current path from terminal E_1, on the output terminal board 7, through the earth conductor 3, conductors 18, 19 contacts 20 on the circuit-breaker A, contacts 21 operated by an armature 22 on the differential current relay C, and thence to the other side of the winding 10.

The circuit-breaker A is closed by means of a push-button 23 against the action of a spring 24, and its construction is such that

voltages is substantially below its correct value the relay or circuit-breaker will remain open and the appliance will be isolated from the supply.

In the case of a single phase supply the current for the operating coil of the relay or circuit-breaker may for example be derived from a potential source comprising the series-connected secondaries of two transformers, the primaries of which are connected respectively one between the conductor intended to be connected to the live terminal of the supply and the conductor intended for earth, the other between that intended for the live terminal and that intended for the neutral. If the three conductors are correctly connected to live, neurtal and earth of the supply, then there will be substantially the full supply voltage across each primary and the resulting secondary voltages, which add up, are arranged to be sufficient to close the relay or circuit-breaker. If, however, any or almost any of the connections are interchanged, or if there is a break in a conductor, one or other or both of the voltages will not appear and the relay contacts will remain open, isolating the appliance from the supply. It will be appreciated that this circuit according to the invention checks the continuity of the earth connection right back to the point of the mains supply where earth and neutral become common.

According to a further feature of the invention provision is made for the passing of a current continuously through the protective earth sheath of the appliance, and any interruption of this current, such as would be caused by damage to the sheath, will isolate the appliance from the supply. For example the current to the operating coil of the relay or circuit-breaker mentioned earlier could be passed through the sheath. In an electrically heated blanket, warming pad, mattress or the like, for example, the heating element may be enclosed in a continuous braided flexible metal covering of which one end is earthed and of which the two ends are connected in series with the transformer secondaries mentioned earlier. Then any fracture of the braided covering will interrupt the supply to the coil of the relay or circuit-breaker (hereinafter referred to as a circuit-breaker) and isolate the appliance.

Two examples of electrical safety devices and a modification will now be described by way of example with reference to the accompanying drawings, in which:—

Figure 1 shows the circuit diagram of one form of the device, also indicating the connections to the appliance.

Figure 2 shows the circuit of a modified form, omitting the differential current relay.

Figure 3 shows a modification which may be embodied in either of the circuits of Figures 1 and 2.

Referring first to Figure 1, this shows a form of the device giving maximum protection. The input terminal board or plug is shown at 1, having terminals N, E and L respectively for connection of the neutral, earth and live connections of a single phase, alternating current supply. Normally the supply will be in the form of one phase of a three-phase alternating current supply network and at some point in the network there will be a star-connected transformer the secondary winding of which has its central star joint earthed. The earth wire of the consumer's installation will normally also be connected to an earthing rod or other conductor buried in the ground, and if all the earth connections are correct this earth path should have a resistance low enough to allow any earth faults to circulate through it.

The device according to the invention has, broady speaking, three conductors 2, 3 and 4 running through it, each broken by a circuit breaker A, and a further circuit breaker B. The live and neutral conductors 2 and 4 each have protective fuses F and series windings 5 and 6 on the outer limbs of a differential current relay C of special construction, to be described later, and then all three conductors lead to an output terminal board or socket 7, which includes an extra earth terminal E_2 in addition to an earth terminal E_1.

A transformer T has a three-limbed core with two primary windings 8 and 9 and, on the central limb, a single low-voltage secondary winding 10. It will be understood that the transformer T may be replaced equally well by two separate transformers having their secondary windings connected in series. One primary winding 8 is connected through a conductor 11, conductor 12, the contacts of a push-button 13, and a fuse 14 between the neutral conductor 2 and live conductor 4. The other primary winding 9 is connected through a conductor 15, and the same conductor 12, contacts 13 and fuse 14 between the earth conductor 3 and live conductor 4.

A connection from one side of the secondary winding 10 is taken through a fuse 16 to the operating coil 17 of the circuit-breaker B and thence to the terminal E_2, and there is a current path from terminal E_1, on the output terminal board 7, through the earth conductor 3, conductors 18, 19 contacts 20 on the circuit-breaker A, contacts 21 operated by an armature 22 on the differential current relay C, and thence to the other side of the winding 10.

The circuit-breaker A is closed by means of a push-button 23 against the action of a spring 24, and its construction is such that

the contacts 20 are only closed when the button 23 is fully depressed and as soon as it is released the moving parts are returned to a small extent by the action of the spring 24, sufficient to open contacts 20 but not the remaining contacts, and the circuit-breaker is held in this position by a mechanical link (indicated diagrammatically at M) with the moving parts of the circuit-breaker B if the latter is energised. On de-energisation of the circuit-breaker B the link M is released and the circuit-breaker A returns to its fully open position.

The circuit-breaker B is closed by energisation of its operating coil 17, deriving its current from the secondary winding 10 of the transformer T.

It is important to note that the sensitivity of the coil 17 is arranged to be such that it will not operate the circuit-breaker B if either of the windings 8 or 9 of the transformer T is not receiving substantially its full voltage to produce in the secondary winding 10 a voltage dependent on the sum of the magnetic fluxes produced by the two primary windings.

The differential current relay C is of three-limbed construction, with a rocking armature 22 pivoted on its centre limb, and provided the current in the winding 5 is not less than that in the winding 6 the armature occupies the position shown, with the contacts 21 closed. An increase in the current in the winding 6, without a corresponding increase in the winding 5 will upset the balance, tilting the armature to open contacts 21 and this also closes a further pair of contacts 25 to illuminate a red pilot light R by connecting it across the mains supply.

A green pilot light G is connected by means of a centre-tap across half the secondary winding 10 of the transformer T, being controlled by extra contacts 26 on the circuit-breaker B.

The appliance which is supplied with current and protected by the device according to the invention is shown diagrammatically in the lower part of Figure 1, and may take the form, for example, of an electrically heated blanket or mattress, an iron, electric drill, vacuum cleaner, food mixer, kettle, or any one of a number of such devices. The current consuming element is indicated at 27 protected by insulation 28 from the exposed metal frame or casing of the appliance shown at 29. Connections are made from two separate points on the metal frame or casing, one to the terminal E_1, and the other to the terminal E_2. For example, where the appliance is a heater, such as the electric heating element of a heated blanket or mattress, the element may be enclosed in a flexible braided metal sheath, and the two ends of the sheath are connected to E_1 and E_2.

The terminal board 7 is conveniently in the form of a socket into which a plug on the end of a four-wire flexible lead from the appliance is inserted.

I will now consider the operation of the device:—

If the device has been correctly connected up to the mains supply, and if the push button 23 is now depressed, the full mains voltage is applied to both the transformer primary windings 8 and 9. The resultant voltage set up in the secondary winding 10 causes a current to flow through the operating coil 17 of the relay B through conductors 18 and 19, contacts 20, terminal E_1, the two earth leads and the metal frame or housing of the appliance, and back to the winding 10. This energises the coil 17 to close the circuit-breaker B and current passes to appliance. At the same time the pilot light G is illuminated by closure of the contacts 26.

When the button 23 is released the contacts 20 open but the mechanical link M holds the remaining contacts closed. The current to the coil 17 is then maintained through the neutral and earth conductors 2 and 3, right back to that point in the mains supply network at which the earth and neutral are joined, usually the star-point of the secondary winding of a three-phase transformer at some point in the network.

Now if any one of a number of different possible faults arises the device will isolate the protected appliance completely from the supply. For example, if the earth leads to the appliance or the metal frame or casing, or in the case of a heating element the braided sheathing, is broken at any point the circuit to the coil 17 is broken, the circuit-breaker B opens, and circuit-breaker A is also opened by the release of the link M. The light G goes out. The same result is achieved if there is any interruption or undesirably high resistance in the earth connections of the supply. If an earth fault develops in the insulation 28 of the appliance then at least part of the current flows through the earth 3 instead of the neutral conductor 2, so that the current in the winding 5 falls, the balance in the relay C is upset, and the contacts 21 are opened, with the same result as before, but in addition the red pilot light R is illuminated to indicate the presence of a fault to earth.

Now if the device had been incorrectly connected in the first place, for example with the live and neutral leads 2 and 4 connected respectively to the neutral and live conductors of the supply, then the winding 9 of the transformer T would have received no current and the output in the secondary winding 10, being half the normal figure,

would be insufficient to energise the coil 17 of the circuit-breaker B.

Likewise, if the earth and live conections were interchanged there would be no current in the primary winding 8, with the same result.

If any time it is desired to trip the device the user has only to depress the button 13, breaking the supply to both the primary windings 8 and 9 of the transformer T. A mechanical link N on this button also enables it to be used to reset the differential current relay C.

It will be seen that the device protects the appliance not only against earth faults, a breakage in the earth leads, or incorrect connection of the appliance, but also against a failure in the continuity of the earth connection of the supply and against any potentially dangerous incorrect connection of the device to the supply. Furthermore the failure of almost any electrical component within the device will cause disconnection of the supply.

The modified form shown in Figure 2 is similar to that of Figure 1 apart from the omission of the differential current relay and a rearrangement of the pilot lights. Corresponding parts have the same reference letters and numerals as in Figure 1. This simplified form of the device is less sensitive than that of Figure 1 in that an earth fault between the current-carrying conductor and the earth leads or housing of the appliance will only be cleared by the blowing of a single fuse F in the live conductor 4, but otherwise the protection is the same, against incorrect connection and against interruptions of earth continuity. Instead of the pilot lights R and G there is a neon lamp P across the live and neutral output leads of the device indicating when current is available at these two points on closure of the circuit-breaker B, and a further neon lamp Q across the fuse F lights up only when that fuse blows.

In certain circumstances, where the mains supply network is such that there may be an appreciable voltage drop in the nuetral conductor, producing a potential difference between neutral and earth, the working of the device may be adversely affected, since this potential difference will appear in series with the voltage of the secondary winding 10 of the transformer T. either augmenting or opposing it, depending on the phase relation ship. Accordingly Figure 3 shows a modification which may be embodied in the device of either Figure 1 or 2 to overcome this difficulty. This comprises simply the insertion of a full-wave rectifier bridge 31 between the output terminals of the secondary winding 10 and the low-voltage circuit it supplies. Then the current circulated though the earth connections of the appliance, through the coil 17, and through the earth and neutral conductors of the supply, is a direct current, and is not affected by any stray alternating current potential differences, which may in any case be bypassed by a capacitor 32.

It will be understood that the arrangement of the pilot lights shown in the Figures may be altered in many different ways without affecting the main purpose of the invention.

The device may be used to protect not only against electrical faults but also against overheating within the appliance it protects, if use is made of the recently developed insulating materials of which the electrical resistance falls comparatively quickly to a low value above a pre-determined temperature. If such a material is used as the insulation 28 between the element and casing of the appliance, then if the element overheats, or if the appliance catches fire, the resulting current path to earth will upset the balance of the differential current relay C and the appliance is isolated. Then when the appliance has cooled and the insulation has recovered its properties, it may be reconnected to the supply. In this way it may be possible, especially for example in electric kettles and in electrically heated blankets and mattresses, to eliminate the need for any of the normally provided protective devices such as low-melting-point links or thermostats.

The device according to the invention is conveniently constructed as a compact unit adapted to be disposed near a domestic wall outlet socket or it may be mounted on the wall in place of such a socket, and it is itself provided with an outlet socket to receive a plug connected to the appliance. The unit may if desired be provided with two or more outlets sockets to accommodate a number of appliances, in which case it is arranged that the insertion of each additional plug interrupts the earth loop and connects in series with it the earth leads and casing of the further appliance.

WHAT I CLAIM IS:—

1. An electrical protective device for interposition between an alternating current mains supply which includes an earth conductor and a current-consuming appliance, the device comprising a relay or circuit-breaker having contacts which open to isolate the apparatus from the supply, the operating coil of the relay or circuit-breaker deriving its operating voltage from a source dependent on the sum of two magnetic fluxes or from the sum of voltages derived from two magnetic fluxes, the fluxes being derived from the voltages across two pairs of conductors of the device, one of these conductors being the earth conductor,

whereby if the sum of the fluxes or of the voltages is substantially below its correct value the relay or circuit-breaker will remain open and the appliance will be isolated from the supply.

2. An electrical protective device according to Claim 1, suitable for a single-phase alternating current supply having a live and a neutral conductor wherein the one magnetic flux is derived from the voltage appearing between the live and neutral conductors of the device and the other between the live and earth conductor.

3. An electrical protective device according to Claim 2, wherein the operating voltage is derived from the secondary winding or windings of a transformer assembly having two primary windings connected respectively across the two pairs of conductors.

4. An electrical protective device according to Claim 3 wherein the transformer assembly comprises a single transformer having two primary windings and a single secondary winding.

5. An electrical protective device according to any of Claims 2 to 4, including a differential current relay connected in the live and neutral conductors of the device and adapted, on the current in the live conductor exceeding that in the neutral conductor, to interrupt the operating circuit of the relay or circuit-breaker operating coil.

6. An electrical protective device according to any of Claims 2 to 5, in which the operating circuit of the relay or circuit-breaker operating coil includes a pair of output terminals of the device adapted to be bridged by an earth loop on the appliance.

7. An electrical protective device according to any of Claims 2 to 6, in which the circuit of the relay or circuit-breaker operating coil includes the earth and neutral conductors of the device and is only completed if the device is connected to the supply and the earth and neutral conductors of the supply have a common point.

8. An electrical protective device accoording to any of Claims 1 to 7 including a manually closed circuit-breaker interrupting all the conductors of the device and disposed electrically between the input terminals of the device and the points of connection to the conductors from which the voltages producing the magnetic fluxes are obtained.

9. An electrical protective device according to Claim 8, in which the manually closed circuit-breaker is urged towards the open position by resilient means but, on closure, is retained in the closed position by a mechanical link engaged only on closure of the coil-operated relay or circuit-breaker.

10. An electrical protective device according to Claim 9, in which the circuit of the relay or circuit-breaker operating coil includes the earth and neutral conductors as specified in Claim 7, and in which the manually closed circuit-breaker includes additional contacts arranged to bridge across between the earth and neutral conductors of the device at points between the contacts of the coil-operated relay or circuit-breaker and the output terminals of the device, these additional contacts being closed on manual operation but re-opened by the resilient means on release, irrespective of the position of the mechanical link.

11. An electrical protective device according to Claim 7 in which the supply circuit to the operating coil includes a rectifier whereby the operating current which circulates through the earth and neutral conductors is unidirectional.

12. An electrical circuit comprising a current-consuming appliance fed through a device according to Claim 6 from an alternating current mains supply, in which the current-consuming element is enclosed in an electrically conducting sheath, and this sheath forms the said earth loop.

13. An electrical circuit comprising a current-consuming appliance fed through a device according to Claim 6, in which the electrical insulation between the current-carrying element of the appliance and the earth loop is of a kind such that its electrical resistance falls above a predetermined temperature.

14. An electrical protective device arranged and connected substantially as described with reference to the accompanying drawings.

BARKER, BRETTELL & DUNCAN,
Chartered Patent Agents,
16 Greenfield Crescent,
Edgbaston,
Birmingham 15.

PROVISIONAL SPECIFICATION.

Protective Device for Electrical Circuits and Apparatus.

I, MICHAEL CORNELIUS GERRARD, a British Subject, of 18 Highfield Road, Cheadle Hulme, Cheshire, do hereby declare this invention to be described in the following statement:—

This invention is concerned with a device for protecting alternating current electrical circuits and apparatus, in particular portable apparatus, against dangers arising through faults and also against those

arising through incorrect connections being made.

A large proportion of portable domestic electrical appliances such as suction cleaners, hair dryers, lawn mowers, electric blankets, portable drills, are at the present day still only fitted with two-core cables, having live and neutral only, and there is no legal compulsion for the provision of an earth conductor. The consequent danger of the appliance becoming electrically live is increased if in addition the leads are connected wrongly to the supply so that the single-pole switch is in the neutral instead of in the live conductor.

Where three pin earthed supply sockets are provided there is still nothing to ensure that three-core cable is used to the appliance, and furthermore even where three-core cable is used there is no certainty that it will be connected correctly. When it is appreciated that there are six different possible ways of connecting three wires to three terminals, only one of which is correct, it will be understood that it is very easy for an appliance to be wrongly connected to a plug by inexperienced hands. Frequently the appliance works satisfactorily and the danger is not realised until an accident results.

Again, even with the appliance correctly wired to the plug, any interruption of the earth conductor will not be detected and the appliance will continue to be used in a potentially dangerous state. In industry the earth connection of portable appliances is often checked by discharging a heavy current through it from a test instrument from time to time, but no such check protects the domestic user of appliances.

The aim of the invention is to overcome these drawbacks and to provide, as far as possible, an effective safeguard both against incorrect connection of the apparatus and against failure of the earth conductor, in addition to the usual fusible links in the supply protecting against overloads and short-circuits.

According to the invention a circuit for connecting an electrical appliance to an alternating current supply, which supply includes an earth conductor, incorporates a relay having contacts which open to isolate the apparatus from the supply, the operating coil of the relay being energised by a magnetic flux derived from a combination of fluxes energised from two different pairs of conductors in the circuit, one of which is the earth conductor, whereby if this magnetic flux is substantially below its correct value the relay will remain open and the appliance will be isolated from the supply.

In the case of a single phase supply the current for the relay coil may for example be derived from a potential source comprising the series-connected secondaries of two transformers, the primaries of which are connected respectively one between the conductor intended to be connected to the live terminal of the supply and the conductor intended for earth, the other between that intended for the live terminal and that intended for the neutral. If the three conductors are correctly connected to live, neutral and earth of the supply, then there will be substantially the full supply voltage across each primary and the resulting secondary voltages, which add up, are arranged to be sufficient to close the relay. If, however, any or almost any of the connections are interchanged or if there is a break in a conductor, one or other or both of the voltages will not appear and the relay contacts will remain open, isolating the appliance from the supply. It will be appreciated that this circuit according to the invention checks the continuity of the earth connection right back to the point of the mains supply where earth and neutral become common.

According to a further feature of the invention provision is made for the passing of a current continuously through the protective earth sheath of the appliance, and any interruption of this current, such as would be caused by damage to the sheath, will isolate the appliance from the supply. For example, the current to the relay coil mentioned earlier could be passed through the sheath. In an electrically heated blanket, warming pad, mattress or the like, for example, the heating element may be enclosed in a continuous braided flexible metal covering of which one end is earthed and of which the two ends are connected in series with the transformer secondaries mentioned earlier. Then any fracture of the braided covering will interrupt the supply to the relay coil and isolate the appliance.

The circuit according to the invention may be conveniently constructed as a unit having three input terminals for connection to the supply and four (or only three if no current is to be passed through the earthed sheath of the appliance) output terminals for connection to the appliance. The unit incorporates the relay, the two transformers (which may be wound on a single core for convenience) and also an earth leakage relay, the coil of which is in series with that conductor which is intended for connection to the earth of the supply and the contacts of which are normally closed and are in series with coil of the main relay. Then any leakage to earth caused by a short circuit from the element or winding of the appliance to the sheath will energise the earth leakage relay which in turn will

interrupt the circuit to the coil of the main relay and the appliance will be isolated.

Both the earth leakage relay and the main relay may include extra contacts controlling the illumination of one or more low voltage lamps visible from outside the unit and indicating the working of the device. The lamps conveniently derive their power from an extra winding on the transformer core.

The unit may also incorporate an on/off switch for the appliance, either single-pole in the live conductor or double-pole in the live and neutral conductors if preferred.

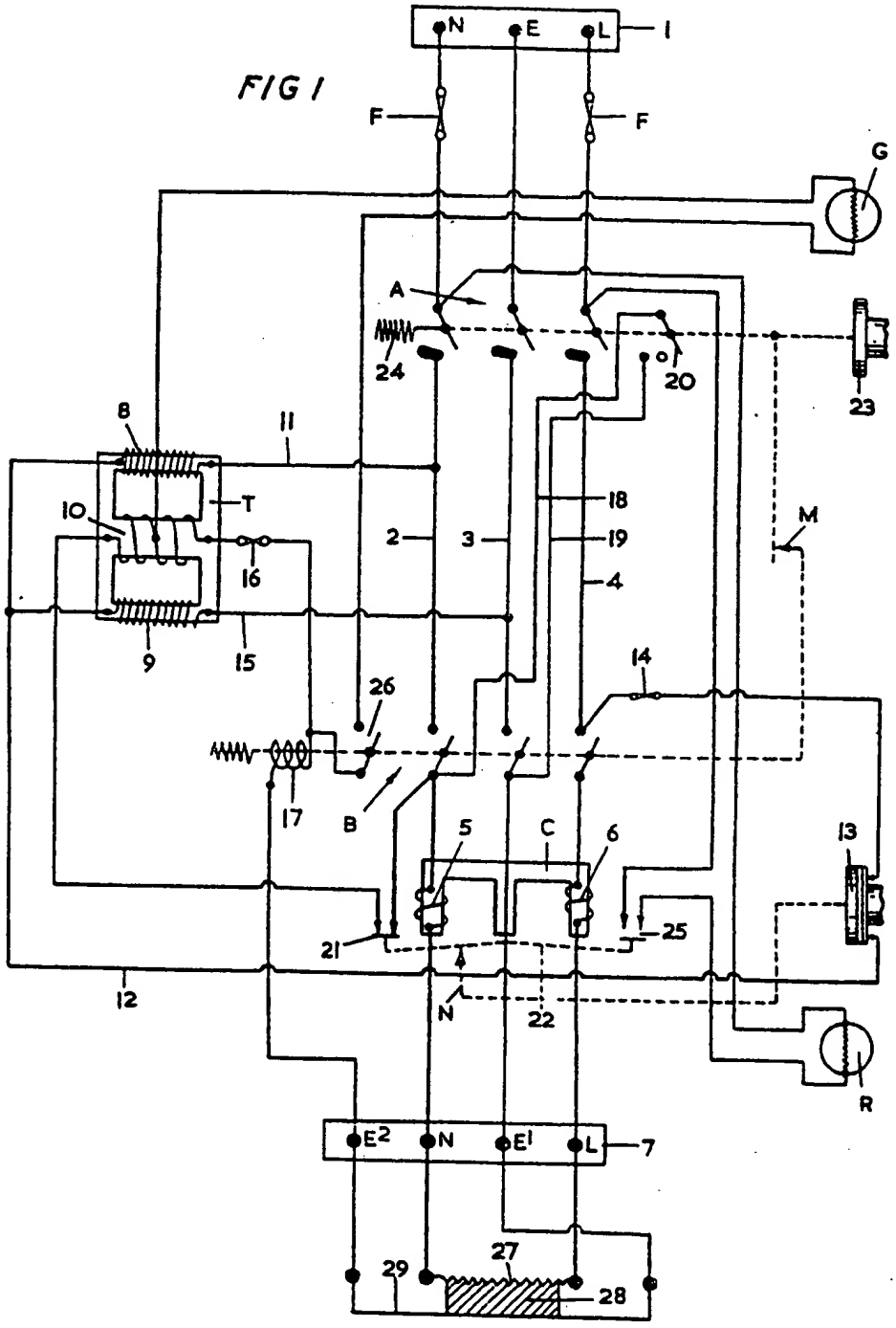
It will be appreciated from the foregoing that the unit will only allow the connection of the appliance to the supply when all three connections to the supply are correctly made and are continuous, and the earth sheath of the appliance itself is unbroken. Thereafter the appliance will immediately be wholly isolated from the supply in the event of (1) any breakage in the continuity of the earthing system anywhere before or after the unit, (2) any breakage in the neutral conductor in or before the device, (3) any breakage in the live conductor in or before the device, and (4) any fault arising which connects to the earth conductor any point in and between the live and neutral conductors.

Whilst the invention has been described with reference to a single-phase supply, it will be understood that it can readily be adapted to give equally effective protection to an appliance fed from a three-phase or other multi-phase supply.

BARKER, BRETTELL & DUNCAN,
Chartered Patent Agents,
75 & 77 Colmore Row,
Birmingham 3.

Abingdon: Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1960.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2,
from which copies may be obtained.

FIG 1


N
E
L
1
F
F
G
A
24
20
23
8
11
T
10
2
3
18
19
4
M
16
9
15
14
26
17
B
5
C
6
13
21
25
12
N
22
R
E2
N
E1
L
7
27
29
28

830,018 COMPLETE SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

FIG 2

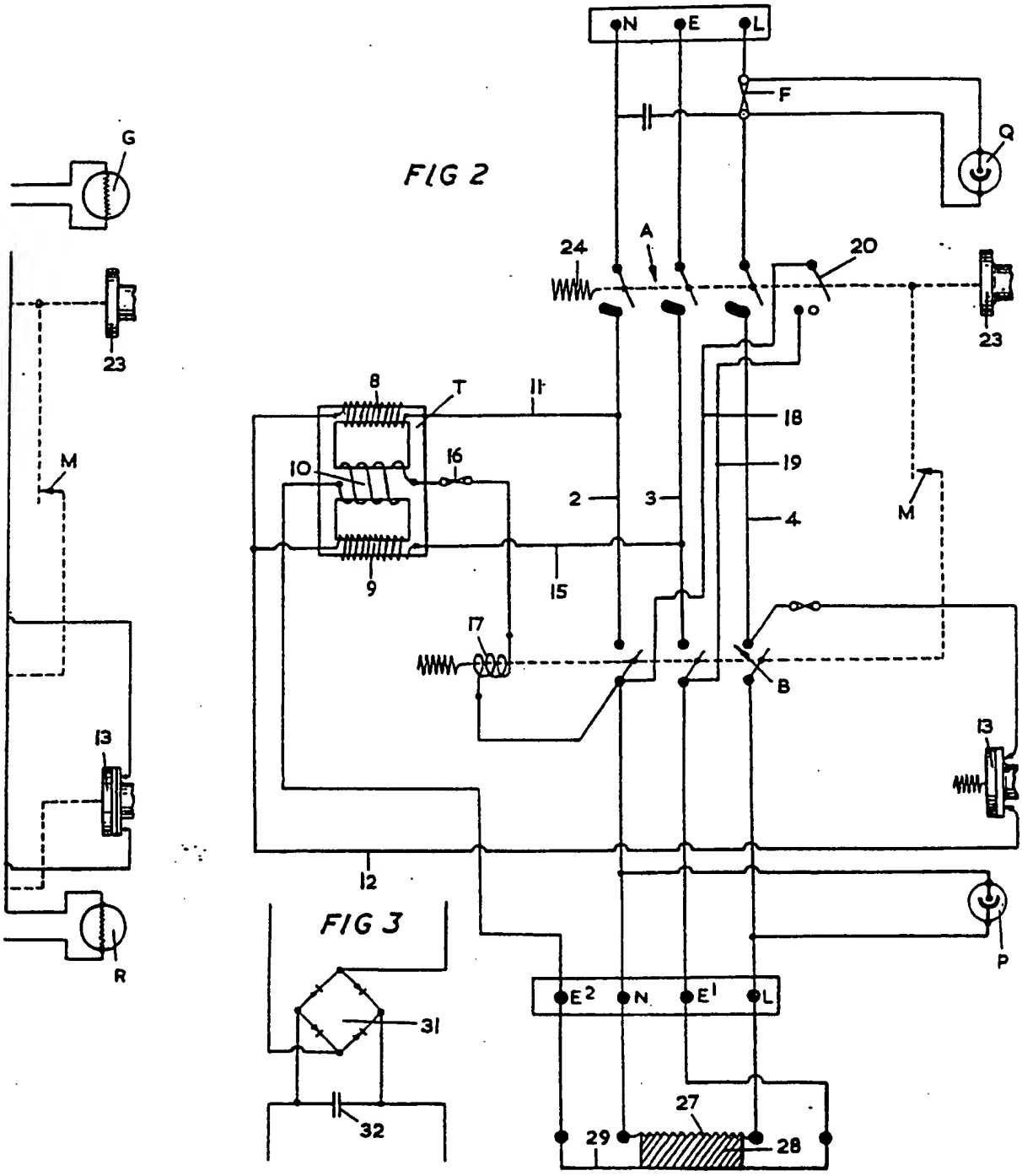


FIG 3

830,018 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEETS 1 & 2

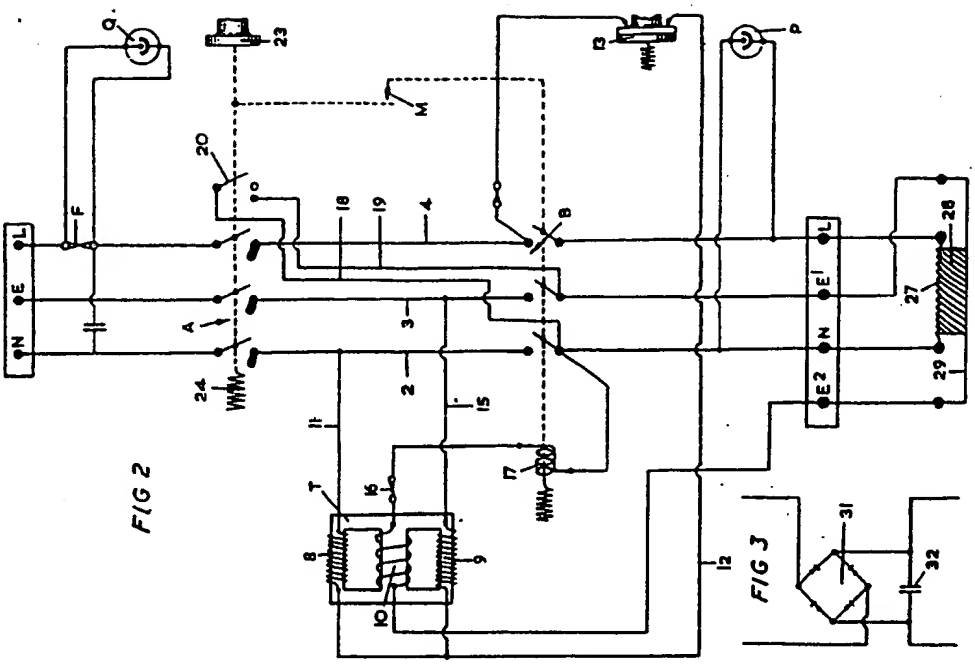


FIG 2

FIG 3

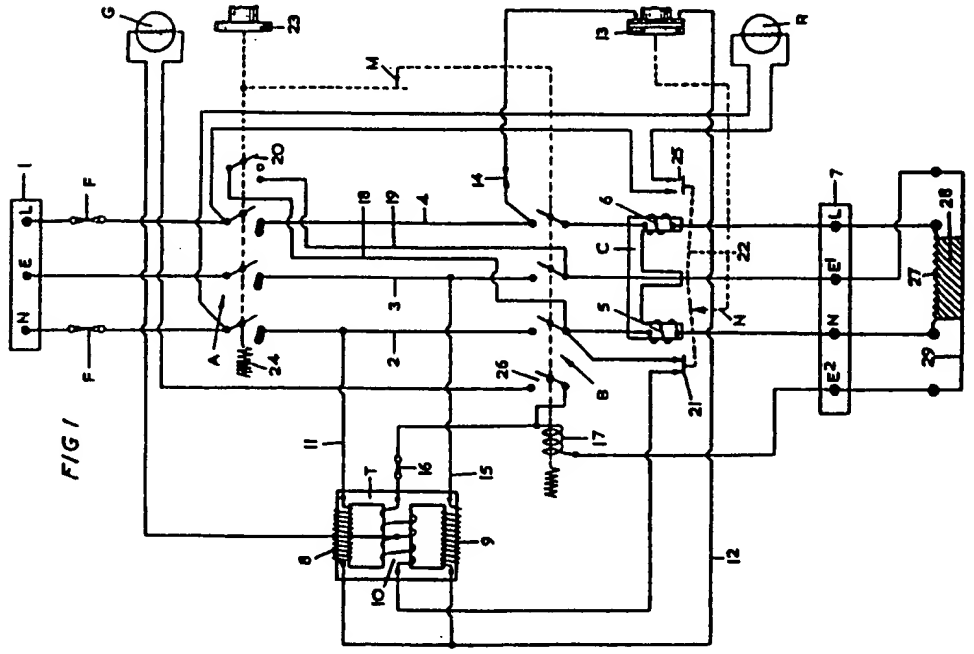


FIG 1